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White Paper



The Printer Working Group

## CWMP Data Models for Printers and MFDs (CWMPMFD)

Status: White Paper

Abstract: The purpose of this white paper is to propose input for future Broadband Forum Technical Reports that would define new data models for printers, multifunction devices (MFDs), other imaging devices that are managed as customer premises equipment (CPE) devices:

- (a) Guidance for remote management of printers and MFDs via Broadband Forum CPE WAN Management Protocol (CWMP) [TR-069];
- (b) Guidance for CWMP Proxy implementations that communicate with printers and MFDs using their native IPP, SNMP, and/or web services, e.g., PWG Print Service;
- (c) Data model for PrintService, with an XML schema binding, that follows the BBF Data Model Template for TR-069-Enabled-Devices [TR-106] and is composed of the machine-translated existing objects, element groups, and elements defined in the PWG Semantic Model v2.0 XML schema; and
- (d) Data models for Scan, Fax, MFD (i.e., System) and various other PWG SM services, that follow the BBF Data Model Template for TR-069-Enabled-Devices [TR-106] and are each composed of the machine-translated existing objects, element groups, and elements defined in the PWG Semantic Model v2.0 XML schema.

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50 manufacturers, print server developers, operating system providers, network operating  
51 systems providers, network connectivity vendors, and print management application  
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53 systems supporting them work together better. All references to the PWG in this  
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55 order to meet this objective, the PWG will document the results of their work as open  
56 standards that define print related protocols, interfaces, procedures and conventions.  
57 Printer manufacturers and vendors of printer related software will benefit from the  
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59 In general, a PWG standard is a specification that is stable, well understood, and is  
60 technically competent, has multiple, independent and interoperable implementations with  
61 substantial operational experience, and enjoys significant public support.

62 For additional information regarding the Printer Working Group visit:

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## 134 **1. Introduction**

135 This document focuses on the evolution of the Managed Print Services (MPS) industry  
136 and the broadband Telecommunications (Telecom) industry and has primary goals of  
137 supporting automatic, remote, secure configuration of newly installed printers and then  
138 securely managing them throughout their lifecycle.

139 Since the mid-1990s, high-quality digital printing technologies have become widespread.  
140 This has led to the convergence of traditional copiers and printers and the subsequent  
141 development of a new class of multifunction devices (MFDs). Older stand-alone office  
142 equipment typically performed a single copy, print, scan, or fax function. Newer MFDs  
143 have evolved to support all of these basic functions and also often include email, resource  
144 management, document transform, document storage, and other imaging services.

145 In recent years, managed print service (MPS) providers have offered proactive supplies  
146 and maintenance service contracts to business, government, and university customers.  
147 The key limitation for MPS market growth has been the lack of a single, comprehensive  
148 monitoring and management interface across the current generation of MFDs.

149 Currently, device and service information about printers is typically available via SNMP  
150 using IETF MIB-II [RFC1213], IETF Host Resources MIB v2 [RFC2790], PWG Imaging  
151 System State and Counter MIB v2 [PWG5106.3], PWG Job Monitoring MIB [RFC2707],  
152 IETF Printer MIB v2 [RFC3805], IETF Finisher MIB [RFC3806], PWG Printer Port Monitor  
153 MIB [PWG5107.1], and PWG Imaging System Power MIB [PWG5106.3].

154 On the other hand, service and job information about printers is typically available via  
155 IPP/1.1 [RFC2911] and often via the newer IPP versions 2.0, 2.1, and 2.2 [PWG5100.12].

156 Currently information about other imaging services and MFDs overall is not available via  
157 open standard interfaces (i.e., the suite of PWG Semantic Model abstract services and  
158 WSDL/SOAP bindings).

159 Meanwhile, the Telecommunications (hereafter, Telecom) service providers have also  
160 changed dramatically. High-speed Internet and other data communications customer  
161 endpoints have become widespread, affordable, and reliable. Older single-function  
162 telecom customer premise equipment [CPE] such as land line telephones, set-top boxes  
163 (STBs), and mobile phones have converged and given rise to multifunction high-speed  
164 media offerings.

165 In the past, telecom infrastructure devices such as routers, bridges, cable modems, and  
166 DSL modems were monitored and managed via SNMP and TELNET/SSH. More recently,  
167 the telecom industry has migrated to the use of Broadband Forum CPE WAN  
168 Management Protocol (CWMP) [TR-069]. And the current generation of CPE devices are  
169 typically also managed using CWMP.

170 Telecom providers have now joined MPS providers as suppliers of printers and MFDs  
171 under service contracts in homes and businesses. Note that current telecom CPE device  
172 have more complex life-cycles than current printers and MFDs. A telecom CPE device is  
173 typically installed with entirely automatic initial configuration and is subsequently  
174 frequently updated with new firmware and new services, again via automatic  
175 configuration.  
176

## 177 **2. Terminology**

### 178 **2.1 Conformance Terminology**

179 Capitalized terms, such as MUST, MUST NOT, REQUIRED, SHOULD, SHOULD NOT,  
180 MAY, and OPTIONAL, have special meaning relating to conformance as defined in RFC  
181 2119 [RFC2119].

### 182 **2.2 Printing Terminology**

183 Normative definitions and semantics of printing terms are imported from IETF Printer MIB  
184 v2 [RFC3805], IETF Finisher MIB [RFC3806], and IETF IPP/1.1 [RFC2911].

185 This document also defines the following protocol roles in order to specify unambiguous  
186 conformance requirements:

187 IPP Client - Initiator of outgoing IPP session requests and sender of outgoing IPP  
188 operation requests (HTTP/1.0 Client [RFC1957] / HTTP/1.1 Client [RFC2616]).

189 IPP Printer - Listener for incoming IPP session requests and receiver of incoming IPP  
190 operation requests (HTTP/1.0 Server [RFC1957] / HTTP/1.1 Server [RFC2616]).

191 SNMP MIB Agent: Listener for incoming SNMP Get and Set management requests and  
192 sender of optional outgoing SNMP notifications for a Printer or MFD (i.e., an SNMP  
193 Agent).

194  
195 SNMP MIB Client: Initiator of outgoing SNMP Get and Set management requests and  
196 receiver of optional incoming SNMP notifications for a Printer or MFD (i.e., an SNMP  
197 Manager).

### 198 **2.3 Telecommunications Terminology**

199 Normative definitions and semantics of telecommunications management terms are  
200 imported from Broadband Forum CPE WAN Management Protocol [TR-069], including the  
201 following:

202  
203 Applied – A change to the Customer Premise Equipment (CPE) configuration has been  
204 applied when the CPE has stopped using the previous configuration and begun using the  
205 new Subunits.

206 Auto-Configuration Server (ACS) – This is a component in the broadband network  
207 responsible for auto-configuration of the Customer Premise Equipment (CPE) for  
208 advanced services.



- 209 Committed – A change to the Customer Premise Equipment (CPE) configuration has  
210 been committed when the change has been fully validated, the new configuration appears  
211 in the configuration data model for subsequent Auto-Configuration Server (ACS)  
212 operations to act on, and the change will definitely be applied in the future, as required by  
213 the protocol specification.
- 214 Customer Premises Equipment (CPE) – Refers to any TR-069-compliant device and  
215 therefore covers both Internet Gateway Devices (IGDs) and LAN-side end devices.
- 216 Data Model – A hierarchical set of parameters that define the managed objects accessible  
217 via [TR-069] for a particular device or service.
- 218 Deployment Unit (DU) – An entity that can be individually deployed on the Execution  
219 Environment. A Deployment Unit can consist of functional Execution Units and/or  
220 configuration files and/or other resources.
- 221 Device – Used interchangeably with CPE in [TR-069].
- 222 Execution Environment (EE) – A software platform that enables the dynamic loading and  
223 unloading of Software Modules. Typical examples include Linux, OSGi, .NET, and Java  
224 ME. Some Execution Environments enable the sharing of resources amongst modules.
- 225 Execution Unit (EU) – A functional entity that, once started, initiates processes to perform  
226 tasks or provide services, until it is stopped. Execution Units are deployed by Deployment  
227 Units. The following list of concepts could be considered Execution Units: services,  
228 scripts, software components, libraries, etc.
- 229 Internet Gateway Device (IGD) – A Customer Premise Equipment (CPE) device, typically  
230 a broadband router, that acts as a gateway between the WAN and the LAN.
- 231 Managed Print Service (MPS) – A service model that adds value to MFDs and printers by  
232 combining provisioning, maintenance, and supplies into Service Level Agreements  
233 (SLAs).
- 234 Parameter – A name-value pair representing a manageable CPE parameter made  
235 accessible to an ACS for reading and/or writing.
- 236 Residential Gateway (RGW) – A gateway between the end user premise and the  
237 broadband service network (i.e., the Telecom network, not the Internet) that is introduced  
238 for architectural clarity in [TR-196].
- 239 Set Top Box (STB) – A television set top box that supports multimedia and Internet  
240 access by the end user.
- 241 Session – A contiguous sequence of CWMP transactions between a Customer Premise  
242 Equipment (CPE) and an Auto-Configuration Server (ACS). Note that a Session may  
243 span multiple TCP connections.

244 Software Module – The common term for all software (except firmware) that will be  
245 installed on an Execution Environment, including the concepts of Deployment Units and  
246 Execution Units.

247 Transaction – A message exchange between a Customer Premise Equipment (CPE) and  
248 an Auto-Configuration Server (ACS) consisting of a single request followed by a single  
249 response, initiated either by the CPE or ACS.  
250

## 251 **3. Requirements**

### 252 **3.1 Rationale for Printer and MFD Management via CWMP**

#### 253 **3.1.1 Rationale from IETF and PWG Perspective**

254 IETF and PWG standards for the printing industry define:

- 255 (a) A rationale for an abstract model of printing (to support alternate encodings and  
256 protocols) in section 3 of the IETF IPP Rationale [RFC2568];
- 257 (b) A set of design goals for status monitoring in a printing protocol in section 3.1.3  
258 'Viewing the status and capabilities of a printer' (for End User), section 3.2.1  
259 'Alerting' (for Operator), and section 3.3 'Administrator' (the bullet requirement to  
260 'administrate billing or other charge-back mechanisms') of the IETF IPP Design  
261 Goals [RFC2567];
- 262 (c) An abstract model of a Print Service (i.e., ISO DPA Logical Printer) and a Print  
263 Device (i.e., ISO DPA Physical Printer) in section 2.1 of IETF IPP/1.1 [RFC2911];
- 264 (d) An abstract model of a Print Device and contained Subunits in section 2.2 of the  
265 IETF Printer MIB v2 [RFC3805];
- 266 (e) An abstract model of Finishing Subunits integrated into the Printer Model (from  
267 [RFC3805]) in section 3 of the IETF Finisher MIB [RFC3806];
- 268 (f) A set of Finishing Subunit types in the 'FinDeviceTypeTC' textual convention in  
269 IANA Finisher MIB [IANAFIN], originally published in section 7 of the IETF Finisher  
270 MIB [RFC3806]; and
- 271 (g) An abstract model of a Multifunction Device in section 2 of the PWG MFD Model  
272 and Common Semantics [PWG5108.01].

273 When deploying printers and MFDs in home and office CPE environments based on  
274 telecom service agreements, initial configuration via SNMP and Embedded Web Server is  
275 neither feasible nor scalable.

276 Therefore CWMP printer and MFD data models SHOULD:

- 277 (a) Standardize native CWMP support for secure operations on printers and MFDs;
- 278 (b) Standardize capabilities to manage, provision, and service these CWMP-based  
279 printers and MFDs;
- 280 (c) Encourage adoption of modern IPP-based printing infrastructures;

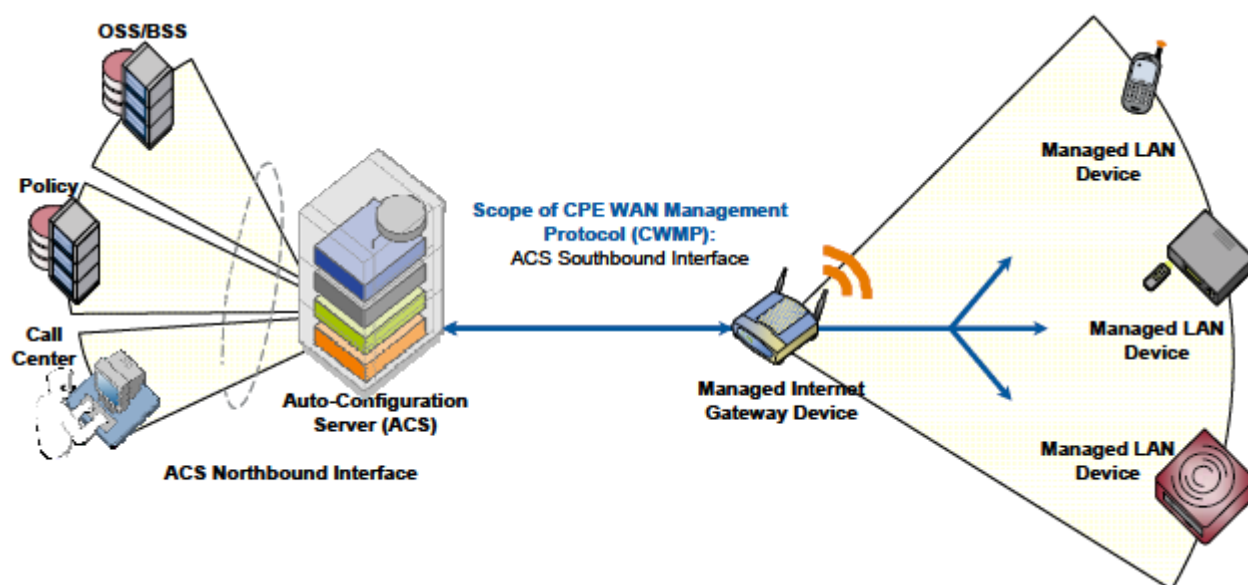
281 (d) Encourage adoption of modern PWG Semantic Model-based MFD infrastructures.

### 282 3.1.2 Rationale from Broadband Forum Perspective

283 The Broadband Forum CPE WAN Management Protocol (CWMP) standard [TR-069]  
 284 defines a set of standard interfaces between the Auto-Configuration Server (ACS) of a  
 285 service provider and all customer premise equipment (CPE) devices in a customer's  
 286 network that supports the CWMP device data model.

287 Figure 1 below is excerpted from section 1.2 of Broadband Forum CWMP [TR-069] and  
 288 depicts the scope of CWMP in an end-to-end WAN network architecture.

289



290

291 **Figure 1 – Broadband Forum CWMP End-to-End Architecture**

292 Implementation of CWMP in MFDs would enable a service provider to offer the following  
 293 advantages throughout the lifecycle of an MFD product:

294 (a) Ease of Deployment: Web-based remote selection, activation, and control of pay-  
 295 per-use services (e.g. print, copy, scan, fax);

296 (b) Touchless Installation: Automatic discovery, secure configuration, and policy-  
 297 based setup of MFDs, printers, and their imaging services that is scalable to  
 298 support many thousands of users according to each user's/group's profile and  
 299 service contract and the customer's business policies (e.g., access control and  
 300 monetization of print, fax, scan, copy and other services based on time, volume,  
 301 user ID, features, payment models, etc.). This is similar to the way mobile phones  
 302 can be remotely identified, configured, and setup on a broadband network today;

303 (c) Remote Device Management: Provides automatic and secure software/firmware  
304 downloads, upgrades, patches, and new value-add services to MFDs, printers,  
305 and other imaging devices – provides automatic performance/status monitoring of  
306 imaging devices and services; and

307 (d) Remote Diagnostics/Troubleshooting: Provides improved problem resolution  
308 capability – eliminates unnecessary and costly device replacement – enhances  
309 customer support process.

310 Broadband Forum CWMP standards for the Telecom industry include:

311 a) A broadband management architecture for CPE devices in CWMP [TR-069];

312 b) A data model template for all devices that support CWMP in [TR106];

313 c) A common device data model in [TR-181];

314 d) An Internet Gateway Device (IGD) data model in [TR-098]; and

315 e) A series of device-specific CWMP data models based on [TR-106] for DSLHome™  
316 for VoIP [TR-104], Set Top Boxes [TR-135], Storage Service enabled devices [TR-  
317 140], and Femto access points [TR-196].

318 There is no currently defined standard TR-069 data model defined for MFDs.

319 By collaborating to propose this MFD data model, the PWG is leading the way for the  
320 inclusion of MFDs and printers as part of the managed services offered by Telecom  
321 operators by leveraging the PWG Semantic Model [PWG5108.1]. In addition, the PWG is  
322 supporting the use of CWMP for MFDs and printers by MPS providers, who will also gain  
323 the advantage of managing any TR-069 enabled device – be it a storage device,  
324 communications device, or a computing device – this CWMP support would allow MPS  
325 providers to evolve into Managed Service Providers (MSPs), in order to compete more  
326 effectively with traditional IT and Telecom service providers.

327

## 328 **3.2 Use Cases**

329 The use cases below are written from the perspective of the End User or local Admin of  
330 the MFD or printer being managed as a CPE device.

### 331 **3.2.1 MFDs managed by Telecom Providers**

332 Customers in home and enterprise environments can use MFDs/Printers that are  
333 deployed and maintained by Telecom providers. When the PWG Semantic Model is  
334 supported in the proposed Broadband Forum data model for MFDs/Printers, Telecom  
335 providers will be able to add these imaging device products into their value added  
336 services as part of their managed services portfolios. A user could purchase or lease a  
337 TR-069 enabled MDF/Printer, plug it into their network, and have the device automatically  
338 securely configured by the Telecom provider's ACS (management server). Based on  
339 which services the user has already subscribed to, the device will be appropriately  
340 provisioned. Telecom providers could negotiate marketing and support contracts with  
341 printer manufacturers for technical support, field service, and toner/supplies replenishment  
342 – this would create a whole new revenue stream through a different channel for the printer  
343 manufacturers.

### 344 **3.2.2 MFDs managed by MPS Providers**

345 Customers in enterprise environments can use MFDs/Printers that have been pre-  
346 configured and shipped with the domain address of the ACS (management server) used  
347 by the MPS provider. When the MFD or Printer is plugged into the enterprise network, the  
348 device will automatically contact the ACS, using its pre-configured credentials. Based on  
349 the services that have been purchased by the customer, the ACS will automatically  
350 securely configure the device (including any firmware updates if necessary). The device  
351 will then be under the control of the MPS provider, who can maintain the SLAs, perform  
352 toner/supplies replenishment, schedule service calls, and perform metering for control of  
353 service levels as well as billing. Through the lifecycle of the product or the service  
354 contract, the device will be managed remotely by the MPS provider. If the customer fails  
355 to pay or does not renew the service contract, then the device and its services can be  
356 disabled remotely by the MPS provider.

### 357 **3.2.3 MFDs managed by Enterprise IT Staff**

358 Enterprise communications infrastructure devices – routers, bridges, VoIP switches, video  
359 telephony servers, etc. – are already typically managed using Broadband Forum CWMP  
360 [TR-069]. By adding CWMP clients to MFDs/Printers, manufacturers can ship devices  
361 that can all be managed from a single ACS. When devices are physically moved between  
362 departments or policies are deployed for usage of these devices – e.g., able to print only  
363 black/white but not color or restrictions of usage by page count – or certain departments  
364 require stronger security than others, this will necessitate remote configuration and  
365 provisioning of these devices. Once a set of policies are created, configuration of these

366 MFD/Printer devices will become automatic instead of based on extensive manual work  
 367 for IT network operators. This would save time, improve enterprise security and ensure  
 368 adherence to policy.

### 369 3.2.4 Print Kiosks managed by Telecom Providers



370

371 **Figure 2 – Print Kiosks and Secure Cloud Print Service**

372 In the Cloud Print use cases below, the mobile phones and print kiosks are managed by  
 373 Telecom providers using CWMP. The mobile phones are managed via Telecom cellular  
 374 networks, while the print kiosks are managed via Telecom broadband networks. The print  
 375 kiosks are monitored for status, provisioned with new services, and remote diagnostics  
 376 are all performed by Telecom providers using CWMP.

#### 377 3.2.4.1 Cloud Print via IPP Everywhere

378 Mobile phone users can access any bundled or 3<sup>rd</sup> party application (Email, Dropbox,  
 379 Photoapp, etc.) that shares their desired document (MS Word, PDF, JPEG, etc.) and  
 380 press the Print button. Using geolocation or other means (default device, last used  
 381 device, etc.) a list of available Print Kiosks from their Telecom's secure Cloud Print  
 382 Service is displayed to the user, who then chooses a "nearby" location (same city,  
 383 neighborhood, building, etc.). The user's print client submits the selected document via  
 384 PWG IPP Everywhere to their Telecom's secure Cloud Print Service specifying the target  
 385 Print Kiosk device.

#### 386 3.2.4.2 Cloud Print via Pull Print

387 Mobile phone users can access any bundled or 3<sup>rd</sup> party application (Email, Dropbox,  
 388 Photoapp, etc.) that shares their desired document (MS Word, PDF, JPEG, etc.) and  
 389 press the Print button. The user chooses delayed printing and the user's client submits

390 the selected document via PWG IPP Everywhere to their Telecom’s secure Cloud Print  
391 Service specifying delayed printing. The user receives a secure job identifier and  
392 associated PIN via email, instant messaging, or in-band from their application. At a later  
393 time, the user queries for a list of available Print Kiosks from their Telecom’s secure Cloud  
394 Print Service and then chooses a “nearby” location (same city, neighborhood, building,  
395 etc.). The user walks up to their chosen Print Kiosk and enters their job identifier and  
396 secure PIN information. The Print Kiosk displays the price for the print job which the user  
397 accepts (adding to their monthly bill). The user’s job is securely pulled from their  
398 Telecom’s secure Cloud Print Service via PWG IPP Everywhere and is printed with the  
399 requested processing options.

### 400 **3.3 Deployment Scenarios**

401  
402 Because the architecture of the Broadband Forum CWMP [TR-069] is highly scalable and  
403 is designed to provide secure remote services in a firewall-friendly manner, several  
404 deployment scenarios can be envisioned. No special ports need to be opened up in  
405 corporate firewalls, nor is reverse VPN tunneling required for service management – both  
406 of which are nightmares for IT security staff.

407  
408 An ACS could be deployed as a service in a public cloud, or in a private cloud for an  
409 enterprise network, or as a private self- deployment by IT staff. Telecom providers could  
410 manage printers in homes, enterprises, and government agencies. MPS providers could  
411 manage multiple enterprises (each of which might have multiple physical sites). Printer  
412 manufacturers could manage printers in SOHO networks, production printing facilities, or  
413 graphic arts companies. Corporate IT staff could deploy CWMP on an in-house server  
414 and then manage devices within their Intranets.

### 415 **3.4 Out of Scope**

416 The CWMP printer and MFD data models must not:

- 417 (1) Define any new content outside the PWG Semantic Model XML schema;
- 418 (2) Define any semantics for workflow applications;
- 419 (3) Define any semantics for document repositories; and
- 420 (4) Define any application-specific semantics for MFD monitoring using CWMP.

### 421 **3.5 Design Requirements**

422 The CWMP printer and MFD data models should:

- 423 (1) Be based on the PWG Semantic Model XML schema definitions;



- 424 (2) Include all content from the PWG Semantic Model XML schema when possible,  
425 e.g., within the limitations of the BBF data model language;
- 426 (3) Follow the naming conventions of the PWG Semantic Model XML schema when  
427 possible, e.g., within the limitations of BBF data model parameter object and  
428 parameter names and name lengths; and
- 429 (4) Preserve the access control semantics of the PWG Semantic Model XML schema,  
430 e.g., PrintServiceStatus abstract elements are read-only.  
431

## 432 **4. CWMP Data Models**

433 This section proposes an outline approach for Broadband Forum [TR-106] data models for  
434 Printers, MFDs, and other Imaging Devices that are technically equivalent to the PWG  
435 Semantic Model [PWG5108.01]. The top-level PrintService object, named according to  
436 the [TR-106] data model conventions, contains the PWG PrintService object.

### 437 **4.1 Technical Approach**

#### 438 **4.1.1 XML Format of BBF CWMP and PWG SM Models**

439 Each Broadband Forum CWMP data model is written as a single *XML document instance*  
440 (.xml) using data model structural elements (model, object, parameter, etc.) and a small  
441 closed set of datatypes that are all pre-defined in a separate external CWMP *XML*  
442 *document schema* (.xsd) which does NOT allow complex datatypes (choices, unions,  
443 sequences, etc.) to be used in parameter definitions (i.e., elements). Instead such  
444 complex datatypes can be translated as: (a) string; (b) list (comma-separated list of  
445 strings), or (c) sub-objects (sequence of parameters).

446 The PWG Semantic Model, on the other hand, is written as a set of *XML document*  
447 *schema* (.xsd) that each define elements using native XML datatypes (as opposed to the  
448 fixed BBF subset) and as well as PWG complex datatypes (e.g., element groups, choices,  
449 unions, etc.). Therefore, the existing element dictionary defined in PwgCommon.xsd can't  
450 simply be converted to a similar BBF data model (e.g., in sequence clauses), since only a  
451 parameter statement can be contained in a BBF object. BBF data models do allow both  
452 object reference and parameter reference imports – this is being explored for  
453 compactness.

#### 454 **4.1.2 Translation of PWG SM into CWMP Data Models**

455 The proposed CWMP PrintService Data Model should be developed as follows:

- 456 a) Define translation rules for the PWG complex datatypes and element groups;
- 457 b) Machine-translate keyword PWG datatypes in “PwgWellKnownValues.xsd” and  
458 “MediaWellKnownValues.xsd” into simple BBF ‘string’ and save as control files –  
459 the authoritative list of standard values remains in the PWG XML Schema and  
460 IANA IPP Registry files.
- 461 c) Machine-translate other PWG datatypes in “ServiceTypes.xsd”, “JobTypes.xsd”,  
462 “DocumentTypes.xsd”, and “WimsType.xsd” into simple BBF types when possible  
463 and save as a control file – convert ‘choice’ and ‘union’ types into simple BBF  
464 ‘string’ or ‘list’ or BBF sub-objects (TBD) – convert ‘sequence’ types into BBF sub-  
465 objects.

- 466 d) Machine-translate the PWG elements dictionary in PwgCommon.xsd into a BBF  
467 parameter dictionary and save as a control file – preserve integer ranges, string  
468 lengths, etc.
- 469 e) Using the control files output from steps (b) to (d) above, machine-translate the  
470 PWG SM PrintService XML schema into an equivalent CWMP Data Model – PWG  
471 SM simple elements can be translated one-to-one into BBF parameters – PWG SM  
472 element groups can be translated into BBF sub-objects – flatten names whenever  
473 possible to shorten fully qualified parameter names – do not translate  
474 PrintServiceCapabilitiesReady (too volatile) and JobTable.ActiveJobs (for security);
- 475 f) Hand-edit this machine-translated CWMP Data Model in order to fix artifacts and  
476 add XML documentation (annotations, comments, etc.).

### 477 4.1.3 Simple Parameter Datatypes

478 Parameters (elements) in BBF data models cannot be defined with syntaxes of sequences  
479 or complex types, so such PWG Semantic Model datatypes should be flattened whenever  
480 possible, to improve efficiency over limited bandwidth WAN connections to the ACS, for  
481 example:

482 PrintServiceCapabilities.PrintDocumentTicketCapabilites.PrintDocumentProcessingCapab  
483 ilities.NumberUp (list of integers)  
484 → PrintService.Capabilities.DocumentProcessing.NumberUp (string)  
485 – comma-separated list of integers

486 PrintServiceStatus.AccessModes (list of keywords)  
487 → PrintService.Status.AccessModes (string)  
488 – comma-separated list of keywords

### 489 4.1.4 Short Parameter Qualified Names

490 Parameters (elements) in BBF data models are always referred to in CWMP operation  
491 requests with fully qualified names (similar to XPath), so redundancy in PWG Semantic  
492 Model path names should be eliminated whenever possible, to improve efficiency over  
493 limited bandwidth WAN connections to the ACS, for example:

494 PrintService.Configuration.Subunits.InputTrays.InputTray  
495 → PrintService.Subunits.InputTray

496 PrintService.Capabilities.PrintJobTicketCapabilities.PrintJobProcessingCapabilities  
497 → PrintService.Capabilities.JobProcessing

498 Note: Since each CWMP parameter has explicit access mode (readOnly vs. readWrite),  
499 PWG SM MarkerSupplyDescription and MarkerSupplyStatus element groups can be  
500 safely folded together into the base CWMP PrintService.Subunits.Marker.MarkerSupply  
501 object, while preserving the access control distinctions of the PWG Semantic Model.

503 **4.2 PWG SM PrintService Model**

504 The PWG Semantic Model root is the System Object shown in Figure 3 below, which  
 505 contains the Services group, which in turn contains the PrintServices group. The CWMP  
 506 PrintService Data Model is derived by a transform of the PWG SM PrintService shown in  
 507 Figure 4 below.  
 508

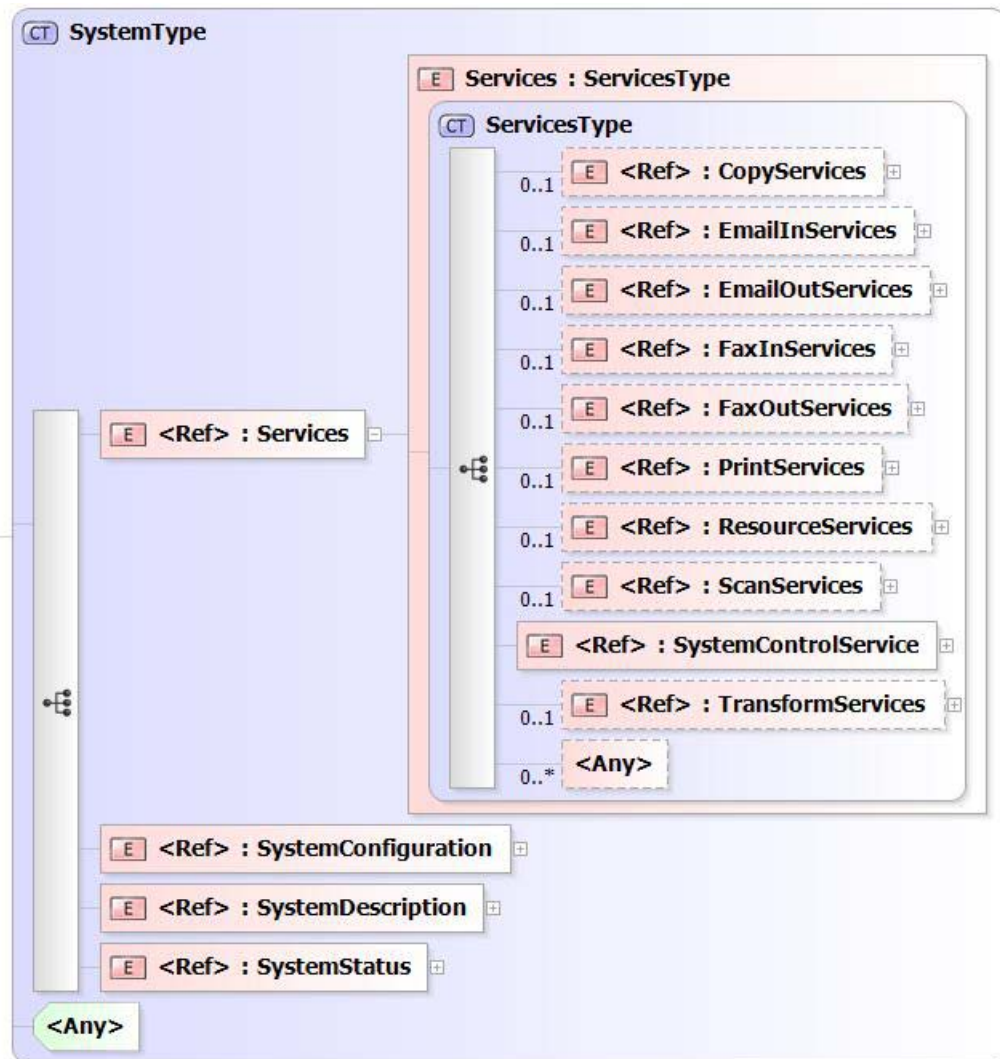
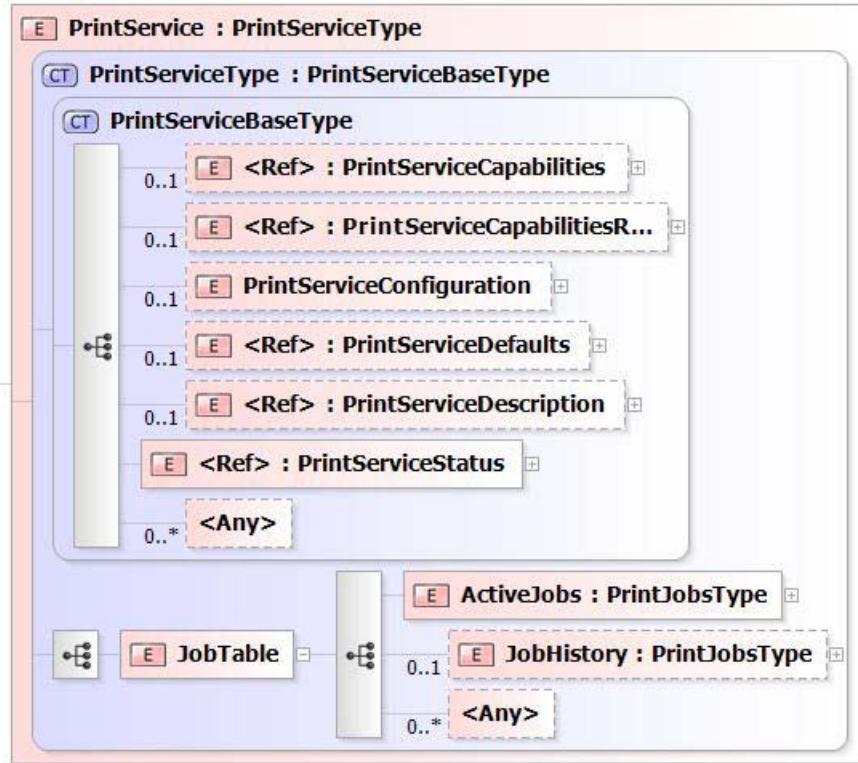


Figure 3 – PWG SM System Object

509  
 510  
 511

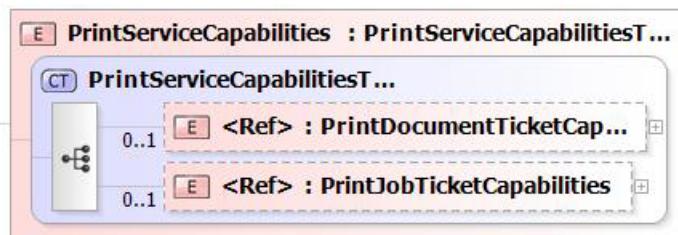


512

513

Figure 4 – PWG SM PrintService Object

514

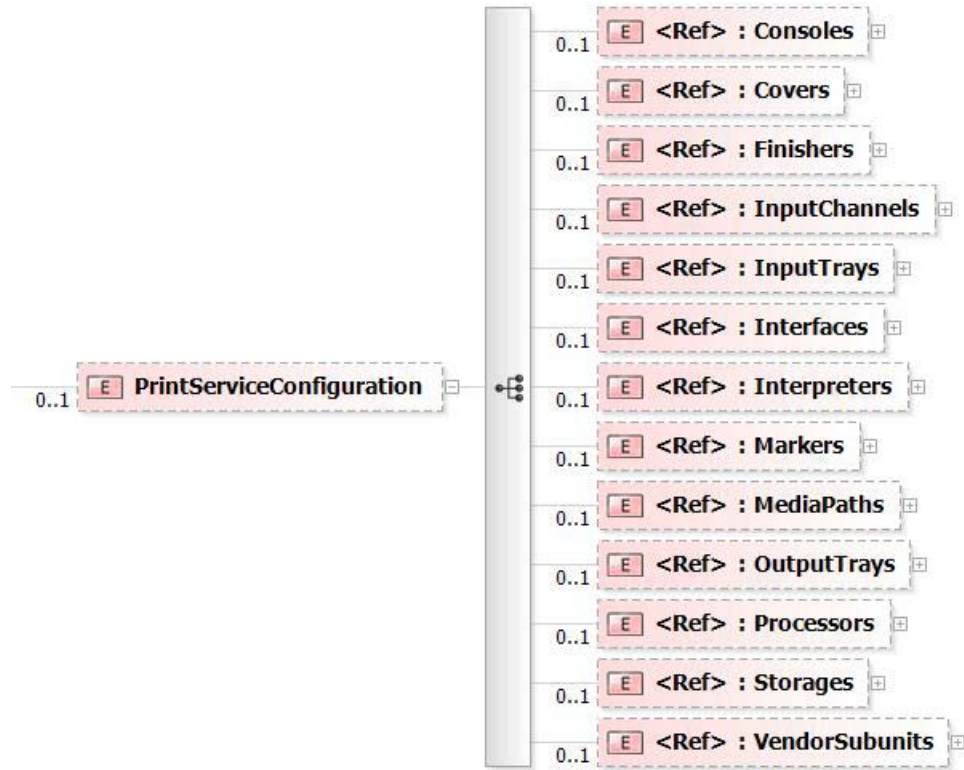


515

516

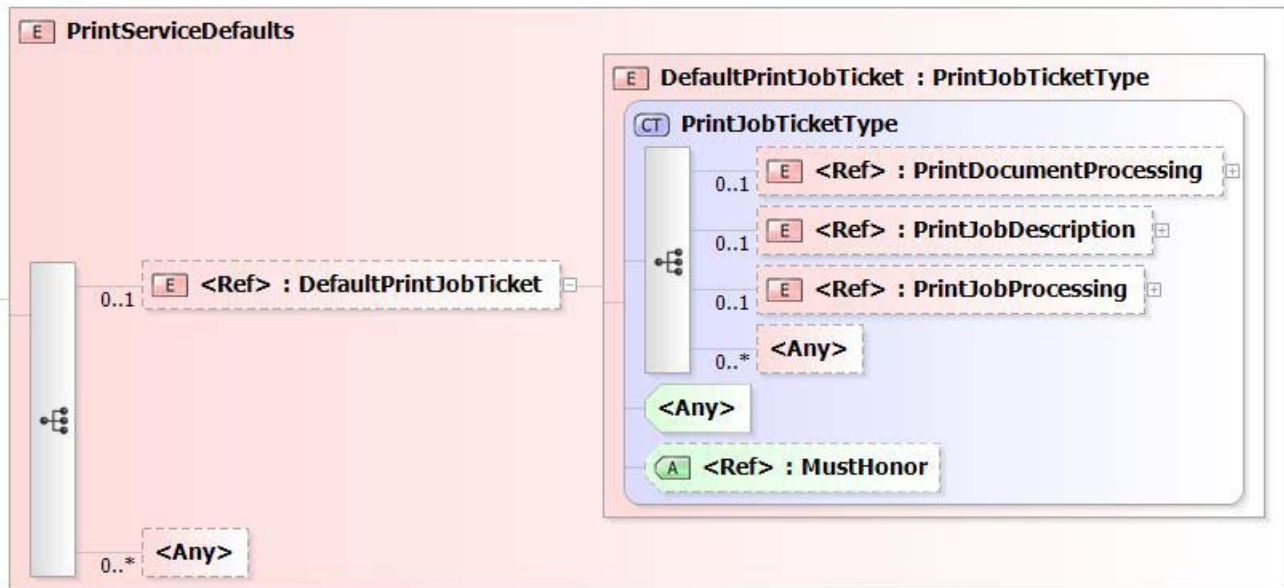
Figure 5 – PWG SM PrintServiceCapabilities Group

517



518  
519  
520

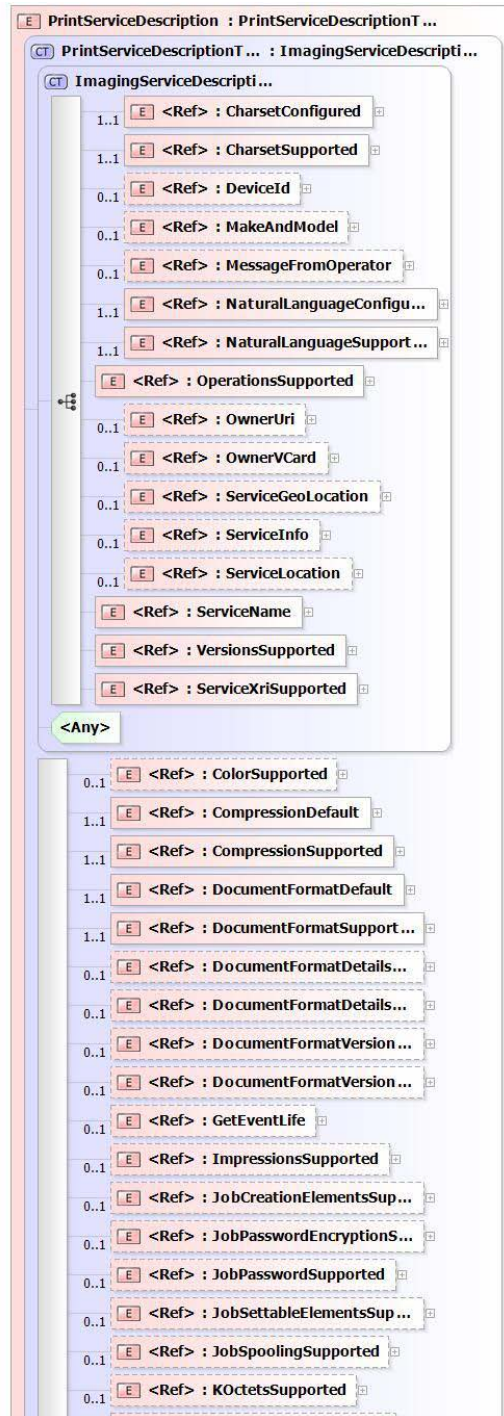
Figure 6 – PWG SM PrintServiceConfiguration Group (subunits)



521  
522  
523

Figure 7 – PWG SM PrintServiceDefaults Group





524

525

526

Figure 8 – PWG SM PrintServiceDescription Group (excerpt)

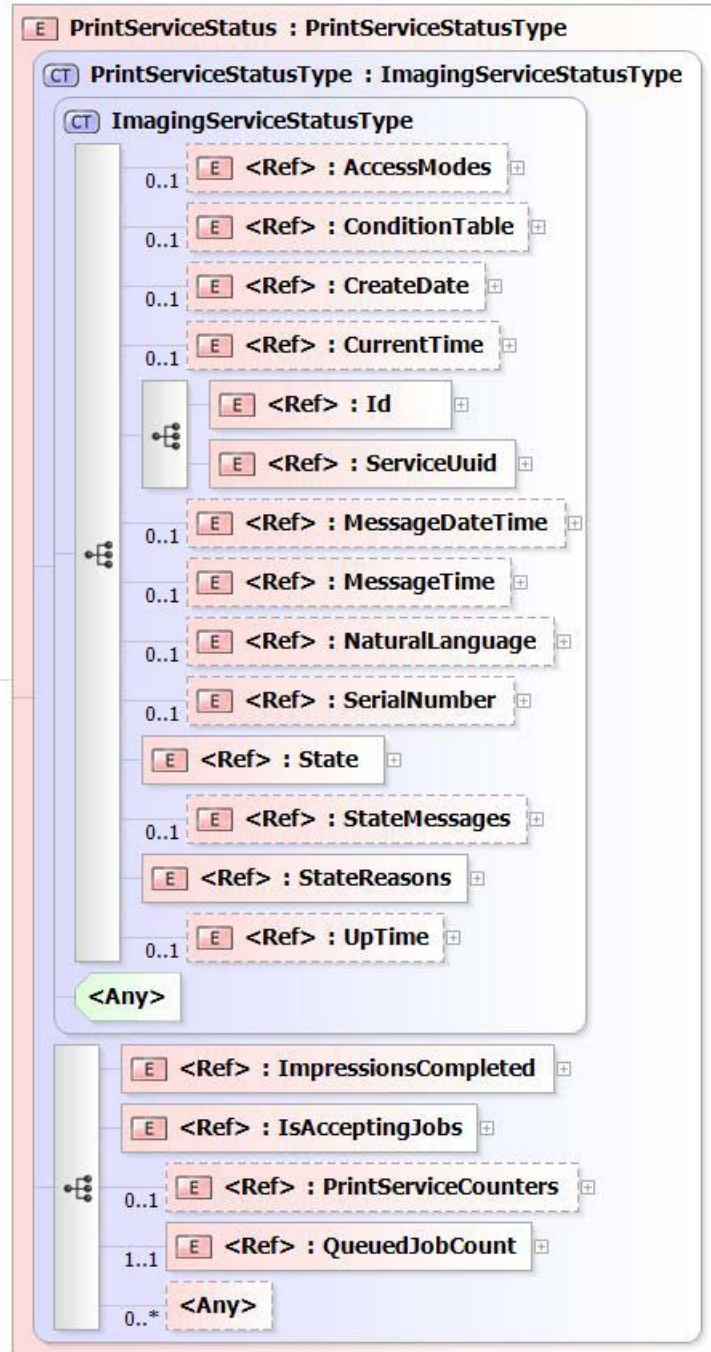


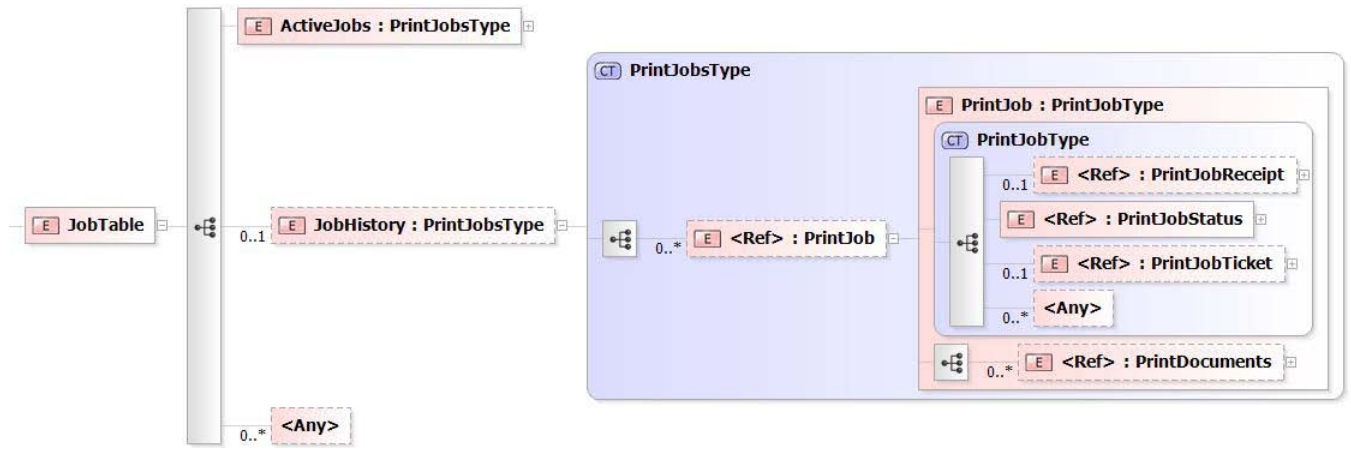
Figure 9 – PWG SM PrintServiceStatus Group

527

528

529

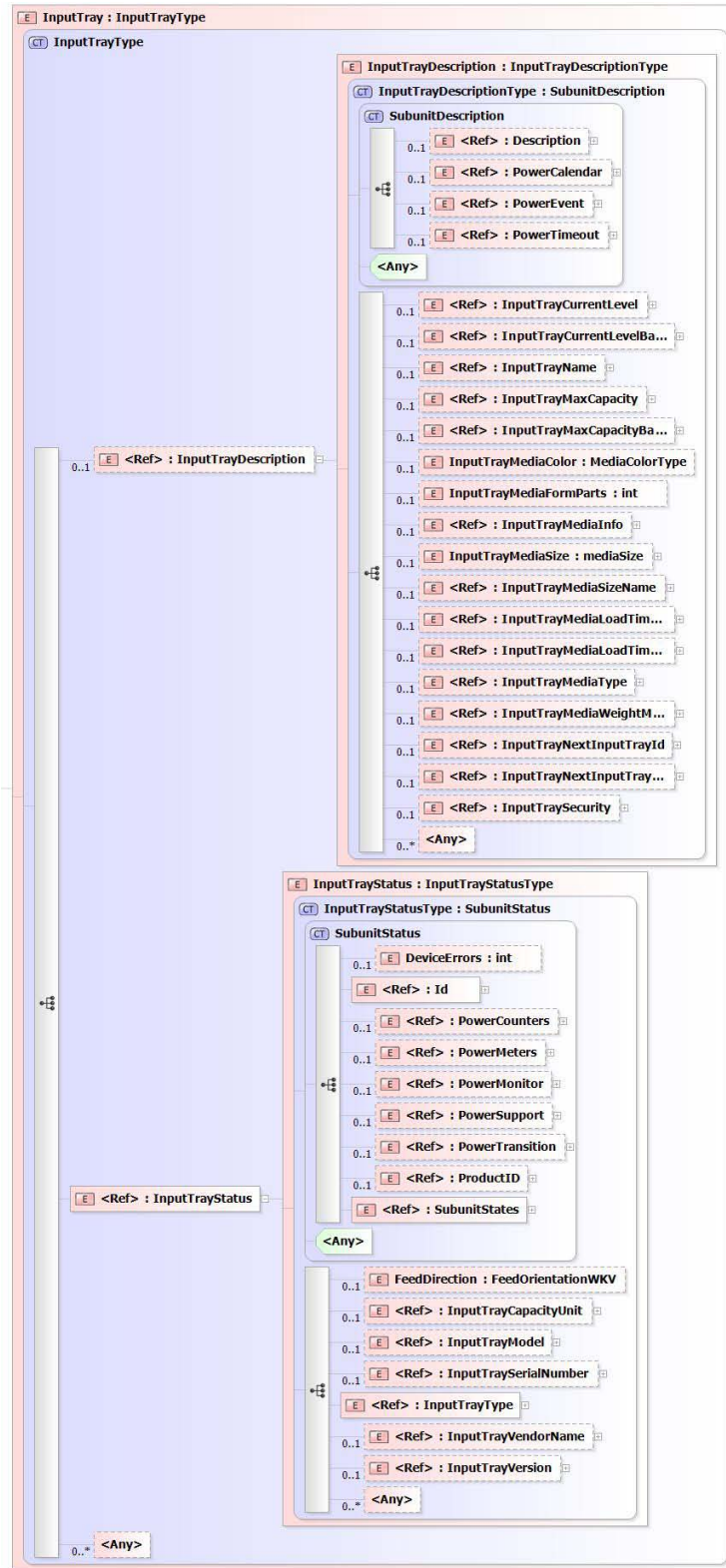




530

531

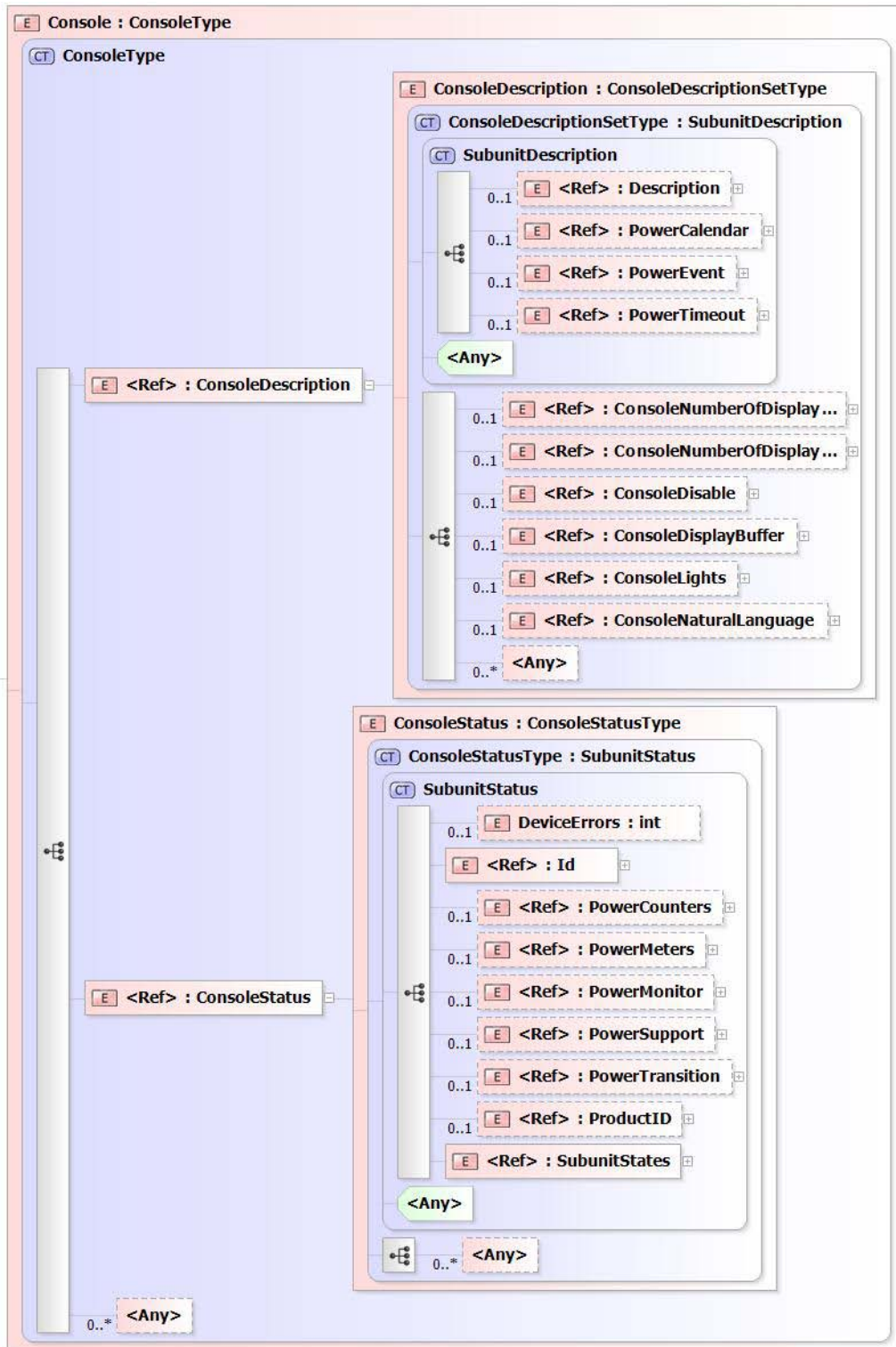
Figure 10 – PWG SM Print JobTable Group (w/ history)



532

533

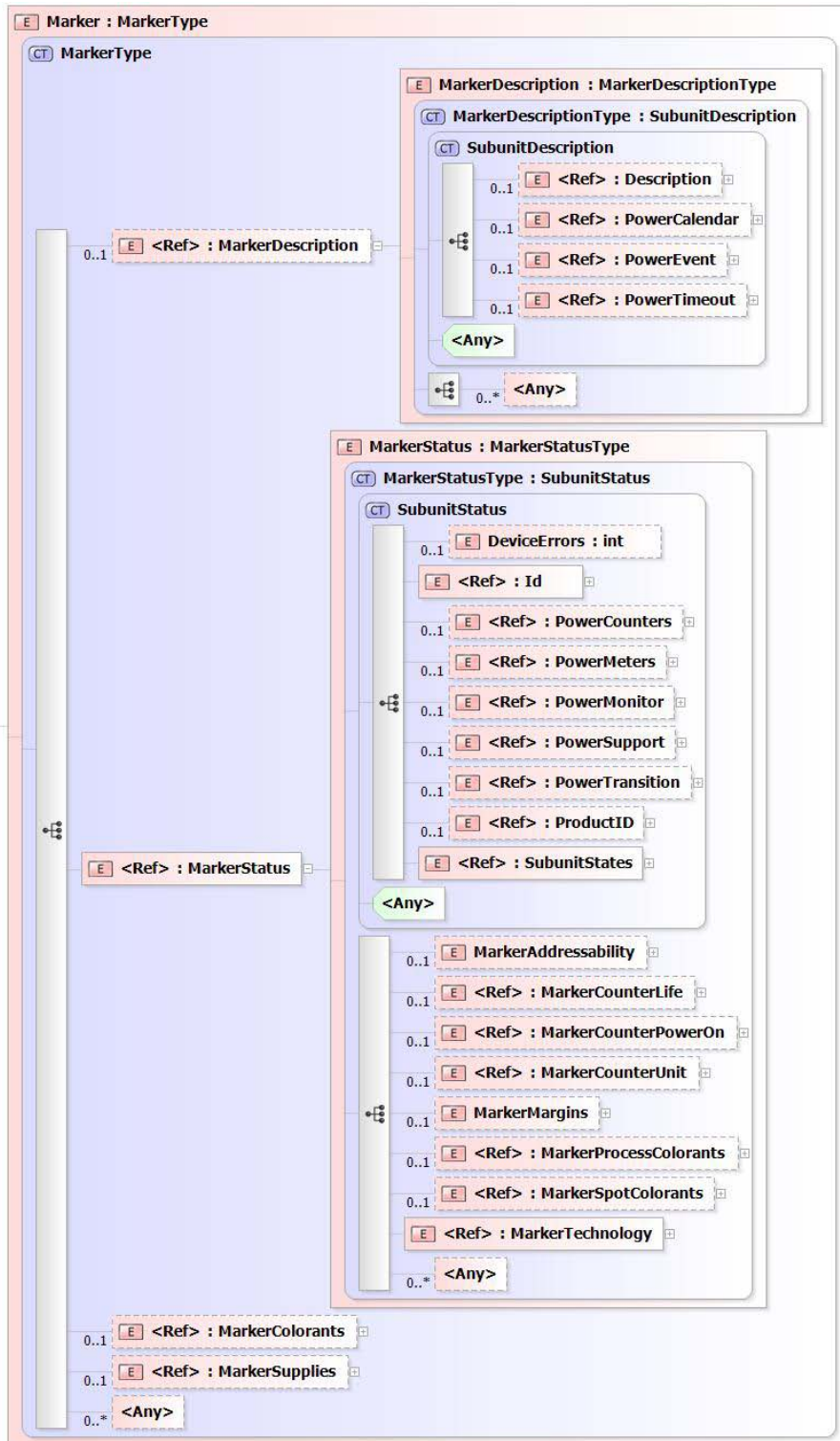
Figure 11 – PWG SM InputTray Object



534

535

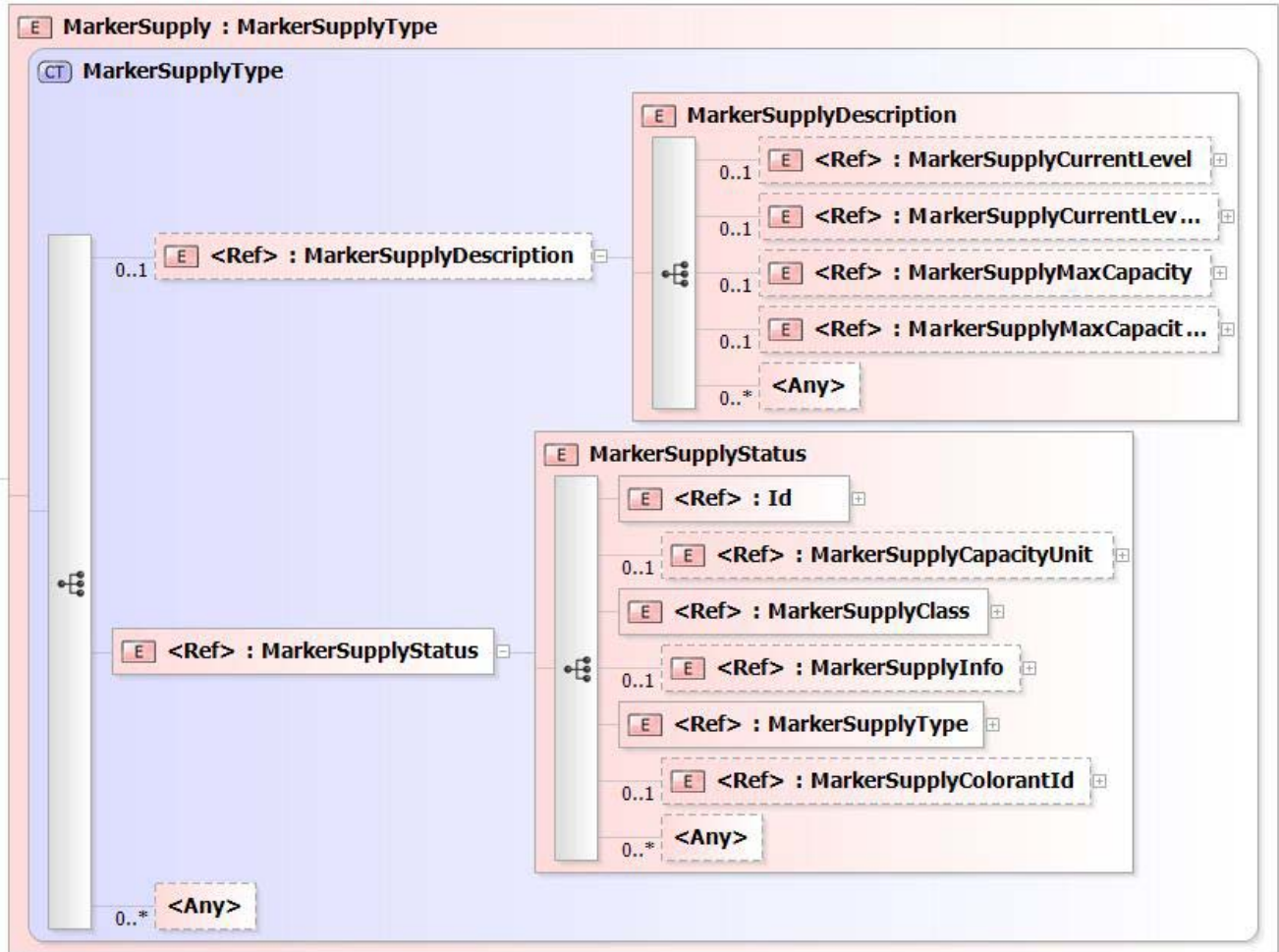
Figure 12 – PWG SM Console Object



536

537

Figure 13 – PWG SM Marker Object



538

539

Figure 14 – PWG SM MarkerSupply Object

540 **4.3 CWMP PrintService Data Model**

541 The following XML document instance fragment of a CWMP PrintService Data Model  
 542 illustrates the proposed approach and some of the difficulties in transforming the existing  
 543 PWG Semantic Model XML document schema into a BBF data model [TR-106].

```

544 <?xml version="1.0" encoding="UTF-8"?>
545 <!-- TR-999 PrintService:1.0 Service Object definition -->
546 <dm:document xmlns:dm="urn:broadband-forum-org:cwmp:datamodel-1-1"
547 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
548 xsi:schemaLocation="urn:broadband-forum-org:cwmp:datamodel-1-1 cwmp-datamodel-1-1.xsd"
549 spec="urn:broadband-forum-org:tr-999-1-0-0">
550 <import file="tr-069-biblio.xml" spec="urn:broadband-forum-org:tr-069-biblio"/>
551 <import file="tr-106-1-0-types.xml" spec="urn:broadband-forum-org:tr-106-1-0">
552 <data type="IPAddress"/>
553 </import>
554 <bibliography>
555 <!-- Set of references here -->
556
```



```

557     <reference id="TR-135">
558         <name>TR-135</name>
559         <title>Data Model for a TR-069 Enabled STB</title>
560         <organization>BBF</organization>
561         <category>TR</category>
562     </reference>
563 </bibliography>
564
565 <!-- CWMP PrintService model with counter of PrintService instances -->
566 <model name="PrintService:1.0" isService="true">
567     <parameter name="PrintServiceNumberOfEntries" access="readOnly">
568         <description>Number of entries in the {{PrintService}} table.
569         </description>
570         <syntax>
571             <unsignedInt/>
572         </syntax>
573     </parameter>
574
575 <!-- CWMP PrintService object with enable/disable -->
576 <object name="PrintService.{i}."
577     access="readOnly" minEntries="0" maxEntries="unbounded"
578     numEntriesParameter="PrintServiceNumberOfEntries">
579     <description>PWG PrintService in Services in the CPE.</description>
580     <parameter name="Enable" access="readWrite">
581         <description>Enables or disables this {{object}} instance.</description>
582         <syntax>
583             <boolean/>
584         </syntax>
585     </parameter>
586 </object>
587
588 <object name="PrintService.{i}.Subunits."
589     access="readOnly" minEntries="1" maxEntries="1">
590     <description>PWG PrintServiceConfiguration in the CPE.</description>
591     <parameter name="InputTrayNumberOfEntries" access="readOnly">
592         <description>Number of entries in the {{InputTray}} table.</description>
593         <syntax>
594             <unsignedInt/>
595         </syntax>
596     </parameter>
597     <parameter name="MarkerNumberOfEntries" access="readOnly">
598         <description>Number of entries in the {{Marker}} table.</description>
599         <syntax>
600             <unsignedInt/>
601         </syntax>
602     </parameter>
603     <parameter name="ProcessorNumberOfEntries" access="readOnly">
604         <description>Number of entries in the {{Processor}} table.</description>
605         <syntax>
606             <unsignedInt/>
607         </syntax>
608     </parameter>
609     <!-- more number of entries parameters for all subunit tables -->
610 </object>
611
612 <object name="PrintService.{i}.Subunits.InputTray.{i}."
613     access="readOnly" minEntries="1" maxEntries="unbounded"
614     numEntriesParameter="InputTrayNumberOfEntries">
615     <description>PWG InputTray in the CPE.</description>
616     <parameter name="Enable" access="readWrite">
617         <description>Enables or disables this {{object}} instance.</description>
618         <syntax>

```

```
619         <boolean/>
620     </syntax>
621 </parameter>
622
623 <!-- PWG InputTrayDescription parameters -->
624 <parameter name="Description" access="readWrite">
625     <syntax>
626         <string/>
627     </syntax>
628 </parameter>
629
630 <!-- PWG InputTrayStatus parameters -->
631 <parameter name="DeviceErrors" access="readOnly">
632     <syntax>
633         <int/>
634     </syntax>
635 </parameter>
636 <parameter name="Id" access="readOnly">
637     <syntax>
638         <int/>
639     </syntax>
640 </parameter>
641 <!-- more parameter definitions that correspond to PWG SM schema elements -->
642 </object>
643
644 <object name="PrintService.{i}.Subunits.Marker.{i}."
645 access="readOnly" minEntries="1" maxEntries="unbounded"
646 numEntriesParameter="MarkerNumberOfEntries">
647     <description>PWG Marker in the CPE.</description>
648     <parameter name="Enable" access="readWrite">
649         <description>Enables or disables this {{object}} instance.</description>
650         <syntax>
651             <boolean/>
652         </syntax>
653     </parameter>
654     <parameter name="ColorantNumberOfEntries" access="readOnly">
655         <description>Number of entries in the {{Colorant}} table.</description>
656         <syntax>
657             <unsignedInt/>
658         </syntax>
659     </parameter>
660     <parameter name="SupplyNumberOfEntries" access="readOnly">
661         <description>Number of entries in the {{Supply}} table.</description>
662         <syntax>
663             <unsignedInt/>
664         </syntax>
665     </parameter>
666
667 <!-- PWG MarkerDescription parameters -->
668 <parameter name="Description" access="readWrite">
669     <syntax>
670         <string/>
671     </syntax>
672 </parameter>
673
674 <!-- PWG MarkerStatus parameters -->
675 <parameter name="DeviceErrors" access="readOnly">
676     <syntax>
677         <int/>
678     </syntax>
679 </parameter>
680 <parameter name="Id" access="readOnly">
```

```

681     <syntax>
682     <int/>
683     </syntax>
684 </parameter>
685 </object>
686
687 <object name="PrintService.{i}.Subunits.Marker.{i}.Supply.{i}."
688 access="readOnly" minEntries="1" maxEntries="unbounded"
689 numEntriesParameter="SupplyNumberOfEntries">
690   <description>Pwg MarkerSupplies in the CPE.</description>
691   <parameter name="Enable" access="readWrite">
692     <description>Enables or disables this {{object}} instance.</description>
693     <syntax>
694     <boolean/>
695     </syntax>
696   </parameter>
697
698   <!-- Pwg MarkerSupplyDescription parameters -->
699   <parameter name="Description" access="readWrite">
700     <syntax>
701     <string/>
702     </syntax>
703   </parameter>
704
705   <!-- Pwg MarkerSupplyStatus parameters -->
706   <parameter name="Id" access="readOnly">
707     <syntax>
708     <int/>
709     </syntax>
710   </parameter>
711   <!-- more parameter definitions that correspond to Pwg SM schema elements -->
712 </object>
713
714 <object name="PrintService.{i}.Subunits.Processor.{i}."
715 access="readOnly" minEntries="1" maxEntries="unbounded"
716 numEntriesParameter="ProcessorNumberOfEntries">
717   <description>Pwg Processor in the CPE.</description>
718   <parameter name="Enable" access="readWrite">
719     <description>Enables or disables this {{object}} instance.</description>
720     <syntax>
721     <boolean/>
722     </syntax>
723   </parameter>
724   <parameter name="PowerCalendarNumberOfEntries" access="readOnly">
725     <description>Number of entries in the {{PowerCalendar}} table.</description>
726     <syntax>
727     <unsignedInt/>
728     </syntax>
729   </parameter>
730   <parameter name="PowerEventNumberOfEntries" access="readOnly">
731     <description>Number of entries in the {{PowerEvent}} table.</description>
732     <syntax>
733     <unsignedInt/>
734     </syntax>
735   </parameter>
736   <parameter name="PowerTimeoutNumberOfEntries" access="readOnly">
737     <description>Number of entries in the {{PowerTimeout}} table.</description>
738     <syntax>
739     <unsignedInt/>
740     </syntax>
741   </parameter>
742 </object>

```



```
743
744 <object name="PrintService.{i}.Subunits.Processor.{i}.PowerCalendar.{i}."
745 access="readOnly" minEntries="1" maxEntries="unbounded"
746 numEntriesParameter="PowerCalendarNumberOfEntries">
747   <description>PWG ProcessorDescription.PowerCalendar in the CPE.</description>
748   <parameter name="Id" access="readOnly">
749     <syntax>
750       <int/>
751     </syntax>
752   </parameter>
753   <parameter name="RequestPowerState" access="readWrite">
754     <syntax>
755       <string/>
756     </syntax>
757   </parameter>
758   <parameter name="CalendarRunOnce" access="readWrite">
759     <syntax>
760       <boolean/>
761     </syntax>
762   </parameter>
763 </object>
764
765
766 <object name="PrintService.{i}.Capabilities."
767 access="readOnly" minEntries="1" maxEntries="1">
768   <description>PWG PrintServiceCapabilities in the CPE.</description>
769   <parameter name="Enable" access="readWrite">
770     <description>Enables or disables this {{object}} instance.</description>
771     <syntax>
772       <boolean/>
773     </syntax>
774   </parameter>
775 </object>
776
777 <object name="PrintService.{i}.Capabilities.JobDescription."
778 access="readOnly" minEntries="1" maxEntries="1">
779   <description>PWG PrintJobDescriptionCapabilities in the CPE.</description>
780   <parameter name="ElementsNaturalLanguage" access="readWrite">
781     <syntax>
782       <string/>
783     </syntax>
784   </parameter>
785   <!-- more parameter definitions that correspond to PWG SM schema elements -->
786 </object>
787
788 <object name="PrintService.{i}.Capabilities.JobProcessing."
789 access="readOnly" minEntries="1" maxEntries="1">
790   <description>PWG PrintJobProcessingCapabilities in the CPE.</description>
791   <parameter name="JobDelayOutputUntil" access="readWrite">
792     <syntax>
793       <string/>
794     </syntax>
795   </parameter>
796   <!-- more parameter definitions that correspond to PWG SM schema elements -->
797 </object>
798
799 <object name="PrintService.{i}.Capabilities.DocumentDescription."
800 access="readOnly" minEntries="1" maxEntries="1">
801   <description>PWG PrintDocumentDescriptionCapabilities in the CPE.</description>
802   <parameter name="DocumentDigitalSignature" access="readWrite">
803     <syntax>
804       <string/>
```

```

805     </syntax>
806   </parameter>
807   <!-- more parameter definitions that correspond to PWG SM schema elements -->
808 </object>
809
810 <object name="PrintService.{i}.Capabilities.DocumentProcessing." access="readOnly"
811 minEntries="1" maxEntries="1">
812   <description>Pwg PrintDocumentProcessingCapabilities in the CPE.</description>
813   <parameter name="NumberUp" access="readWrite">
814     <description>Comma-separated list of allowed integer values</description>
815     <syntax>
816       <list/>
817       <int/>
818     </syntax>
819   </parameter>
820   <!-- more parameter definitions that correspond to PWG SM schema elements -->
821 </object>
822
823 <!-- skip Pwg PrintServiceCapabilitiesReady - not interesting over broadband -->
824
825 <object name="PrintService.{i}.Defaults."
826 access="readOnly" minEntries="1" maxEntries="1">
827   <description>Pwg PrintServiceDefaults in the CPE.</description>
828   <parameter name="Enable" access="readWrite">
829     <description>Enables or disables this {{object}} instance.</description>
830     <syntax>
831       <boolean/>
832     </syntax>
833   </parameter>
834 </object>
835
836 <object name="PrintService.{i}.Defaults.JobDescription."
837 access="readOnly" minEntries="1" maxEntries="1">
838   <description>Pwg PrintJobDescription in the CPE.</description>
839   <parameter name="ElementsNaturalLanguage" access="readWrite">
840     <syntax>
841       <string/>
842     </syntax>
843   </parameter>
844   <!-- more parameter definitions that correspond to PWG SM schema elements -->
845 </object>
846
847 <object name="PrintService.{i}.Description."
848 access="readOnly" minEntries="1" maxEntries="1">
849   <description>Pwg PrintServiceDescription in the CPE.</description>
850   <parameter name="CharsetConfigured" access="readWrite">
851     <syntax>
852       <string/>
853     </syntax>
854   </parameter>
855   <!-- more parameter definitions for all PrintService description -->
856 </object>
857
858 <object name="PrintService.{i}.Status."
859 access="readOnly" minEntries="1" maxEntries="1">
860   <description>Pwg PrintServiceStatus in the CPE.</description>
861   <parameter name="AccessModes" access="readOnly">
862     <description>Comma-separated list of access mode keywords</description>
863     <syntax>
864       <list/>
865       <string/>
866     </syntax>

```

```
867     </parameter>
868     <parameter name="ConditionNumberOfEntries" access="readOnly">
869       <description>Number of entries in the {{Condition}} table.</description>
870       <syntax>
871         <unsignedInt/>
872       </syntax>
873     </parameter>
874     <parameter name="CreateDate" access="readOnly">
875       <syntax>
876         <string/>
877       </syntax>
878     </parameter>
879     <!-- more parameter definitions for PrintService status -->
880 </object>
881
882     <!-- profile statements - i.e., imported profiles start here -->
883 </model>
884 </dm:document>
```

885

886

887 **5. Conformance Requirements**

888 Provide a list of conformance requirements for the standard.

889 **6. Internationalization Considerations**

890 For interoperability and basic support for multiple languages, conforming implementations  
891 MUST support the UTF-8 [RFC3629] encoding of Unicode [UNICODE] [ISO10646].

892 **7. Security Considerations**

893 Provide security considerations for this specification.

894 **8. IANA Considerations**

895 Provide IANA registration information for this specification.

896 Subsections include IANA registration templates using the Example style:

897       Some IANA registration text.

898

## 899 9. References

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## 989 **11. Change History**

### 990 **11.1 December 5, 2011**

991 Fifth draft.

- 992
- 993 - Nancy Chen revised PrintService sketch in section 4.3 to fix XML syntax and
  - 994 editing errors to allow correct display in Altova XML Spy – thanks!

### 995 **11.2 December 3, 2011**

996 Fourth draft.

- 997
- 998 - Revised Abstract, Introduction, etc., to reflect phased approach – PrintService first,
  - 999 then other Scan, Fax, MFD, etc., data models per CWMP BOF discussions.
  - 1000 - Added new section 4.1 Approach to Technical Approach, for clarity.
  - 1001 - Added new section 4.2 PWG Semantic Model Print Service, with current PWG SM
  - 1002 figures for System, PrintService, all top groups w/in PrintService, and selected
  - 1003 Subunits to clarify the mapping.
  - 1004 - Moved former section 4.1 to section 4.3 CWMP PrintService Data Model per
  - 1005 CWMP BOF discussions.
  - 1006 - Revised section 4.3 to remove secondary Device.Config and Device.UserInterface
  - 1007 objects – changed to service-centric model of STB (TR-135) and Storage (TR-140).

### 1008 **11.3 September 26, 2011**

1009 Third draft.

- 1010
- 1011 - Corrected various typos per Nancy Chen, Ranga Raj, and Laxman J. Bhat.
  - 1012 - Revised section 3.2.4 Print Kiosks managed by Telecom Providers to add
  - 1013 introduction to Cloud Print use cases and notion of management/provisioning of the
  - 1014 Print Kiosks by Telecom providers per Laxman J. Bhat.
  - 1015 - Revised section 4.1 MFDSERVICE Model to use correct Secondary Common Objects
  - 1016 of Device.Config and Device.UserInterface per Laxman J. Bhat.

1017

### 1018 **11.4 September 21, 2011**

1019 Second draft.

- 1020
- 1021 - Revised section 3.1 Rationale to include content from Nancy Chen.



- 1022 - Revised section 3.2 Use Cases to include content from Ranga Raj.
- 1023 - Added section 3.3 Deployment Scenarios to include content from Ranga Raj.
- 1024 - Revised section 4 MFD Data Model for CWMP to explain machine translation.
- 1025 - Revised section 4.1 MFDSservice Model to add realistic excerpts from PWG SM.

1026 **11.5 September 14, 2011**

1027 Initial draft.